THE CIRCULAR FAÇADE
The new paradigm of regenerative building

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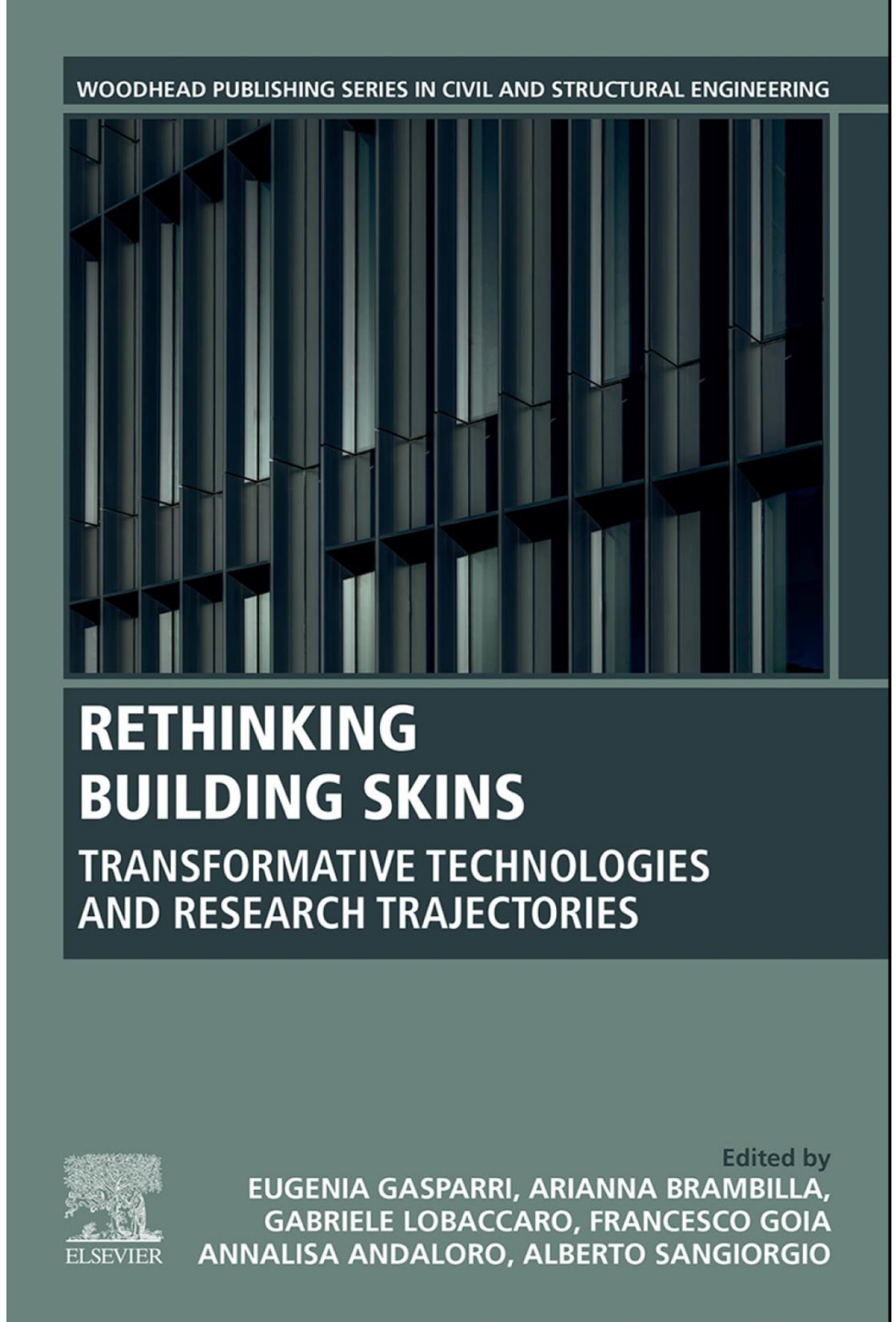
THE GLASS CONVENTION NORDIC 2024
COPENHAGEN, 19/08/2024

image credits: Quentin Olbrechts



Circular economy in facades

21

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Abbreviations

3R	reduce, reuse, recycle
AI	artificial intelligence
BAMB	buildings as material banks
BIM	building information modelling
BIPV	building-integrated photovoltaics
BM	business model
C&D	construction and demolition
C2C	Cradle-to-cradle
CE	circular economy
CEBMs	circular economy business models
CLC	closed-loop cycles
DfD	design for disassembly
GDP	global domestic product
IEQ	indoor environmental quality
IGU	insulating glazing units
LCA	life cycle assessment
MEP	mechanical, electrical and plumbing
RFID	radio-frequency identification
UMAR	urban mining and recycling
XR	extended reality

21.1 Introduction

Increased human activity and rapidly rising global population put enormous pressure on energy supply, which results in increasing consumption of fossil fuels and urgency to transition to renewable sources. However, carbon emissions are just part of the challenges we face in an era of climate change and the biodiversity crisis. Within the broader sustainable development agenda, there are many actions and approaches that have the potential to create a perfect storm for a rethink of design and construction processes. The global challenges require new mindsets

Rethinking Building Skins. DOI: https://doi.org/10.1016/B978-0-12-822477-9.00016-4

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SUSTAINABLE DEVELOPMENT GOALS

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Engineers Declare Climate and Biodiversity Emergency

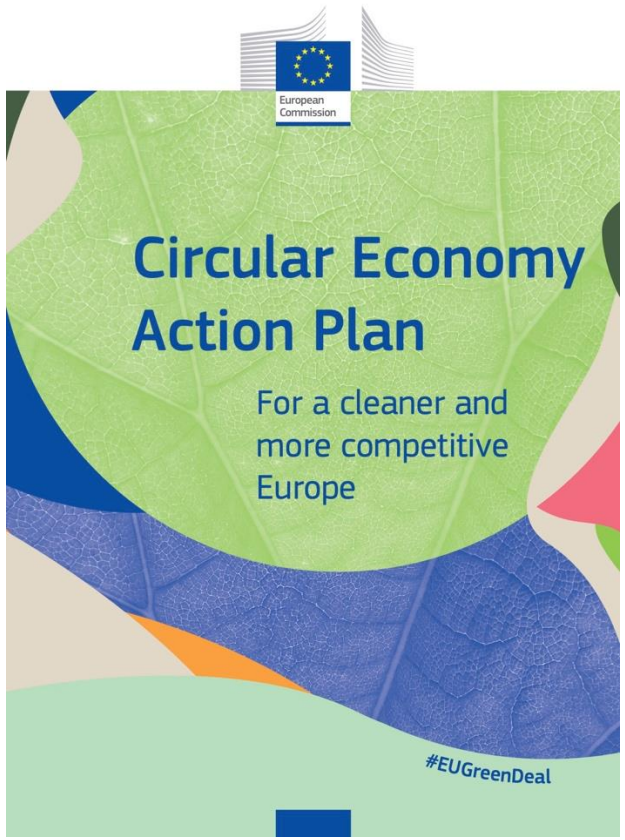
#EngineersDeclare

ENGINEERS DECLARE is a global petition uniting all strands of the built environment engineering profession. It

CIRCULAR ECONOMY

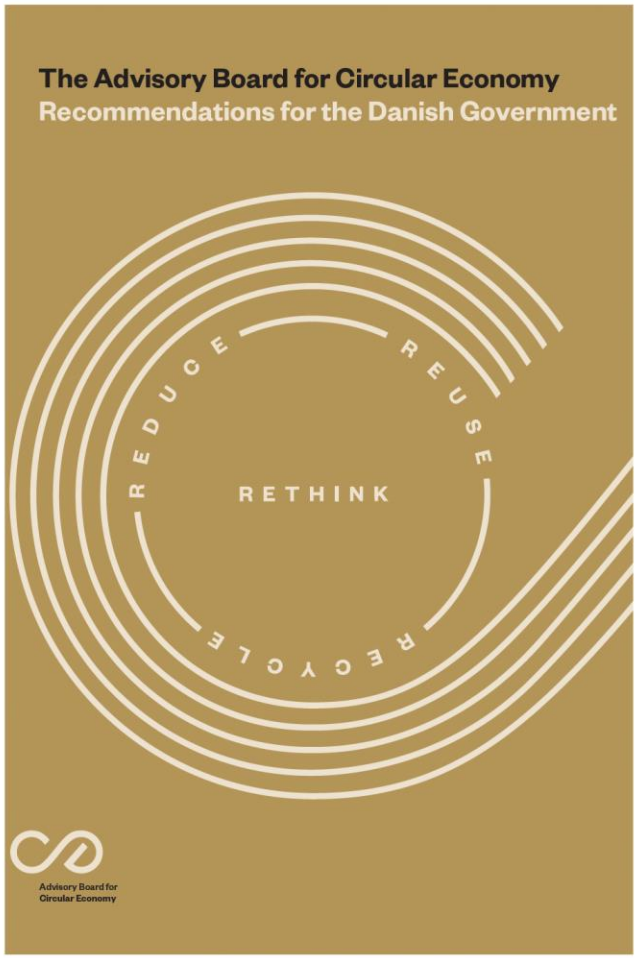
GLOBAL CIRCULAR VISION
Publications

image credits: Ellen Macarthur Foundation



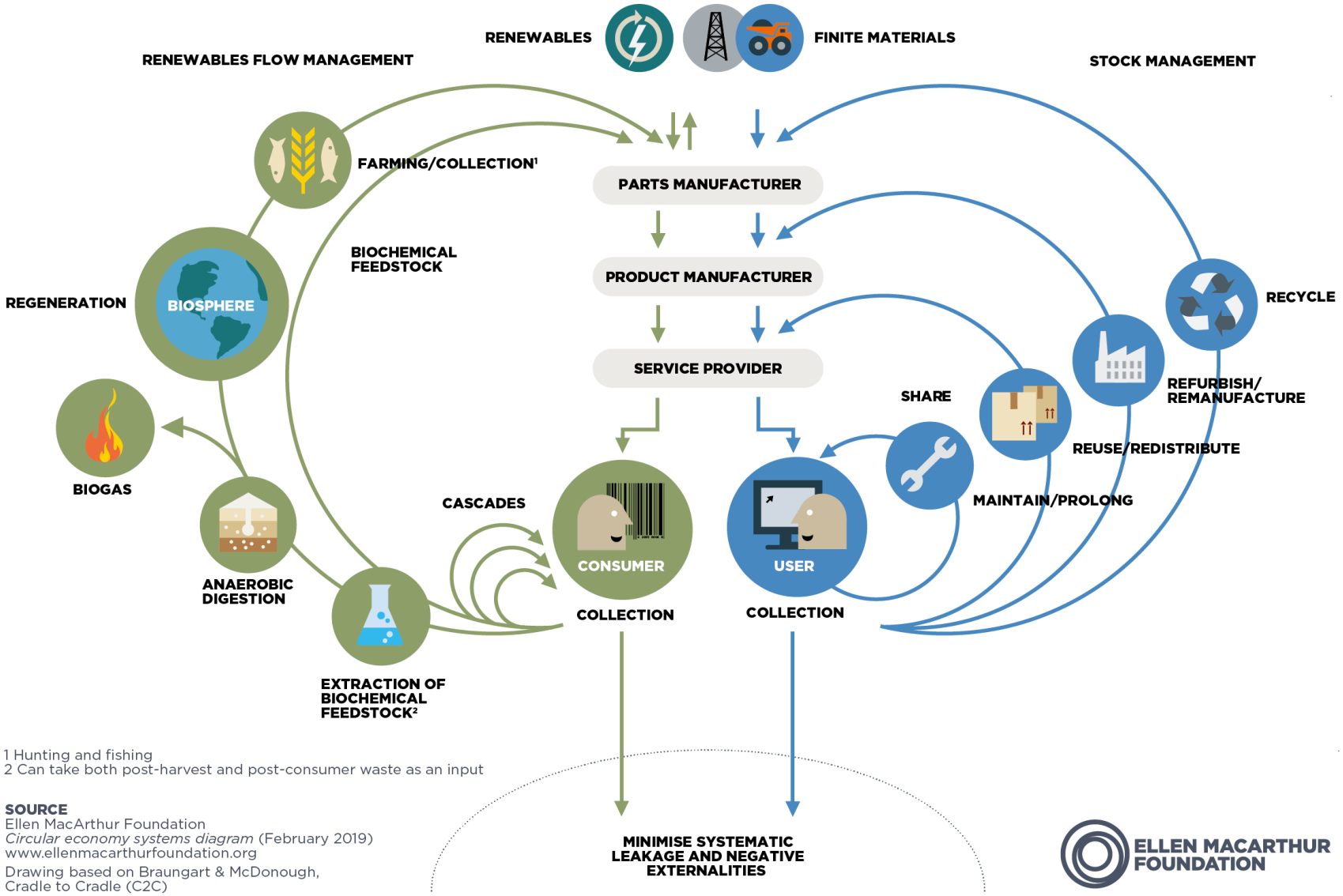
CIRCULAR ECONOMY

EU CIRCULAR VISION
Publications



CIRCULAR ECONOMY

DENMARK´S CIRCULAR VISION
Publications



1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input

SOURCE
Ellen MacArthur Foundation
Circular economy systems diagram (February 2019)
www.ellenmacarthurfoundation.org
Drawing based on Braungart & McDonough, Cradle to Cradle (C2C)

CIRCULAR ECONOMY

THE BUTTERFLY DIAGRAM
Ellen Macarthur Foundation

PHASE	EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITY
PLANNING	1. Planning compact cities – dense, mixed-use, and transit-oriented 2. Planning for local circular material flows
DESIGNING	1. Designing for adaptable and flexible use 2. Using collaborative design processes 3. Integrating material choices into design 4. Taking inspiration from nature
MAKING	1. Sourcing materials strategically 2. Building with resource-efficient construction techniques 3. Building 'buildings as material banks' (BAMB)
ACCESSING	1. Accessing residential space through shared-use schemes 2. Accessing commercial space through shared-use schemes 3. Increasing the use of space through design features
OPERATING AND MAINTAINING	1. Using smart technology to run buildings effectively 2. Using product-as-a-service models for building fit-outs 3. Adapting buildings for alternative uses 4. Refurbishing buildings to run them efficiently

EXAMPLES OF BENEFITS	
Strengthening local communities Mixed-use neighbourhoods that encourage walking are most likely to be associated with positive social encounters and a strong sense of community. Surveys show that people in high-density, walkable communities are more likely to trust or socialise with their neighbours, volunteer or vote.[14]	COMMUNITY AND SOCIAL PROSPERITY
Reducing air pollution Green façades can lead to a reduction in concentrations of particulate matter by 10–20% in the immediate surroundings.[15]	HEALTH AND ENVIRONMENT
Lowering unemployment Integration of circular economy principles in the construction supply chain of 70,000 new homes in Amsterdam before 2040 can generate 700 additional jobs. The approximately 1% gain would be a significant contribution, resulting in a 10% drop in unemployment in the construction sector.[16]	JOBS, SKILLS, AND INNOVATION
Increasing utilisation In London, peer-to-peer renting, better urban planning, office sharing, repurposed buildings, and multi-purposed buildings increases the value of new buildings and can double utilisation of 20% of London's buildings by 2036, saving over GBP 600 million annually.[17]	ECONOMIC PRODUCTIVITY
Reducing energy consumption through refurbishment Through simple refurbishment solutions, it is possible to reduce energy consumption by 20–30% in existing buildings.[18] Deep refurbishment can cut building-related energy consumption in Europe up to 80%, saving the EU over 30% of its total energy use (equivalent of 4 billion barrels annually).[19]	RESOURCE USE

CIRCULAR ECONOMY

OPPORTUNITIES AND BENEFITS
Ellen MacArthur Foundation And Arup

image credits: EMF and ARUP

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This publication thoroughly calculates the effects of Building a Circular Future on a 42.000 m² representative case study office building with a new built value of DKK 860 million.

A positive business case

Redesigning the case study building and implementing circular economy principles, turns the current demolition costs of the building into a positive business case.

Go from todays DKK 16.000.000 in demolition costs.

To a future with DKK 35.000.000 in business upside.

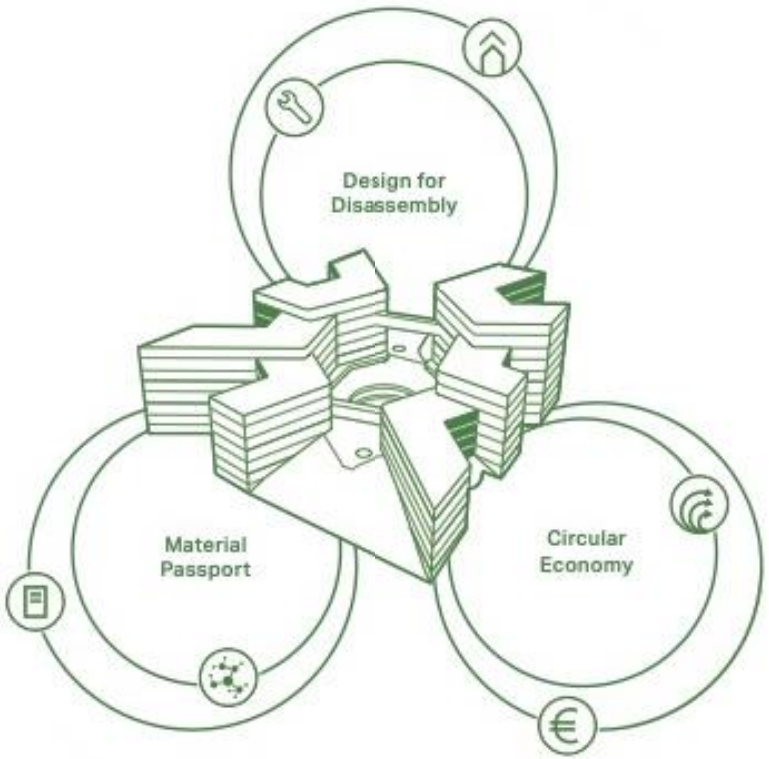
Resale earnings

The resale value of the case study compared to turn key cost. Due to ressource scarcity; earnings will increase over time.

Earn 4% of the new build value on the superstructure and envelope, in todays material prices.

Earn 8% of the new build value on the entire building, in todays material prices.

Earn 16% of the new build value on the entire building, in +50 years in projected material prices.



Prerequisites for reuse

To prepare buildings for a circular future todays building practice has to integrate the following.

Material passport establish functionality information at component level.

Circular Economy implement business models that supports a circular transition.

Design for disassembly make all joints visible, mechanical, disolvable, similar and common.

Immediate and short term gains

Implementing circular principles creates immediate gains and a flexible building from day one.

Improved flexibility by easier adaptation of buildings and functions.

Faster construction by shortening drying times and optimizing workflow.

Optimized maintanance by simple connection logic and detailed information at component level.

CIRCULAR ECONOMY

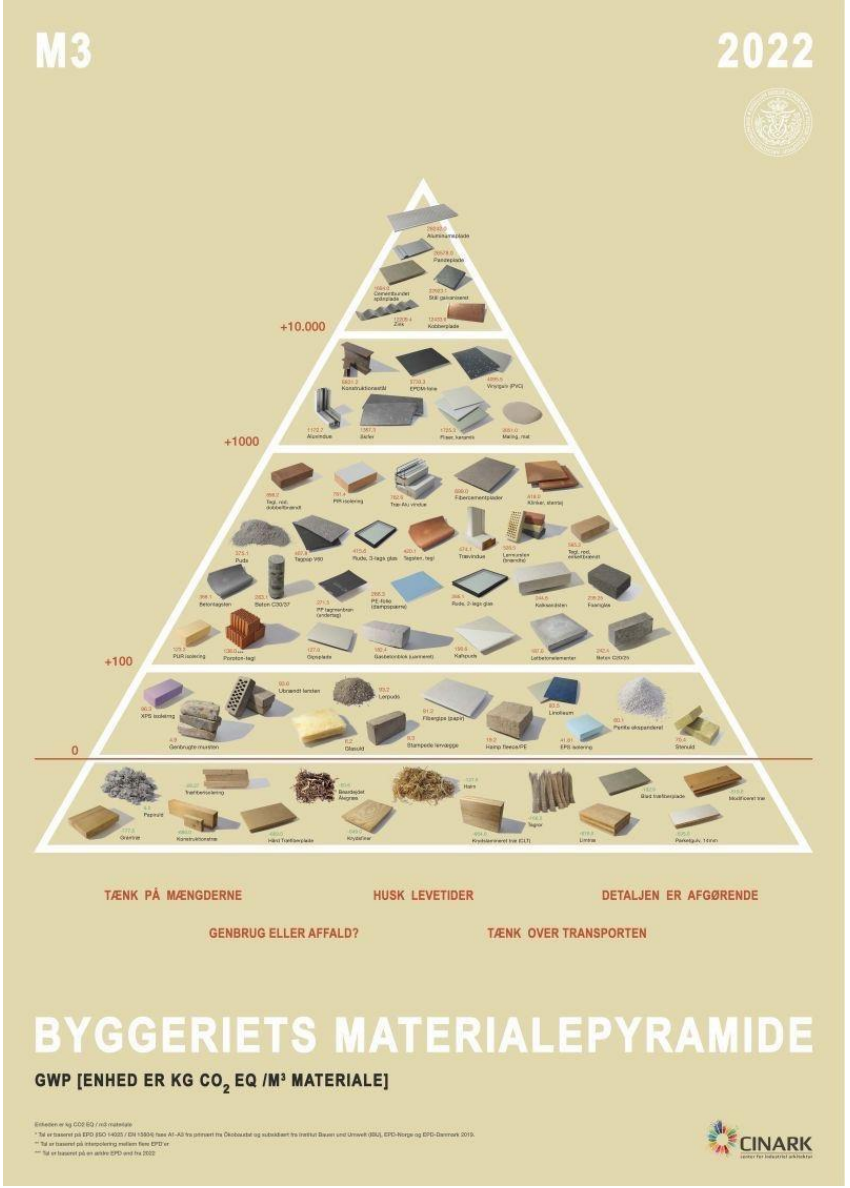
BUILDING A CIRCULAR FUTURE
GXN

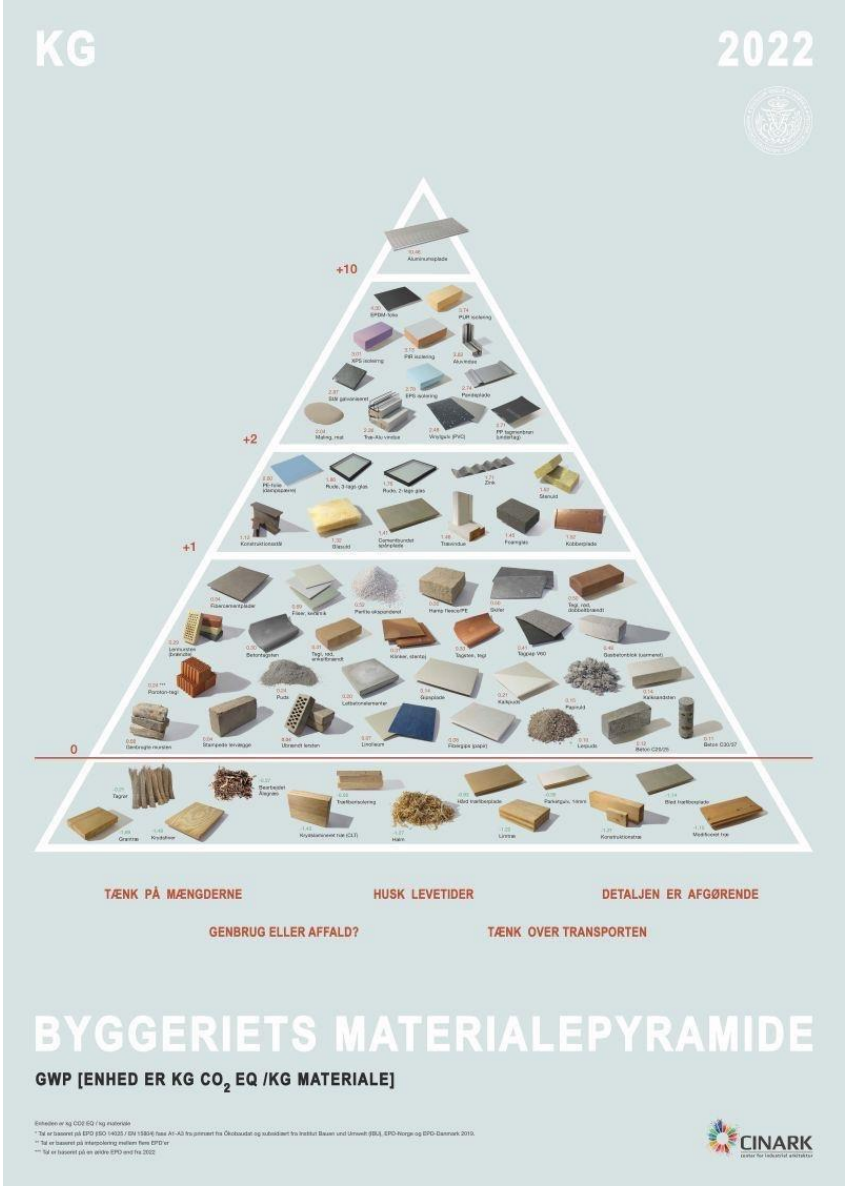
image credits: GXN

3R: REDUCE, REUSE, RECYCLE

PRIMARY SCHOOL IN GANDO, BURKINA FASO
Francis Kéré

image credits: Siméon Duchoud

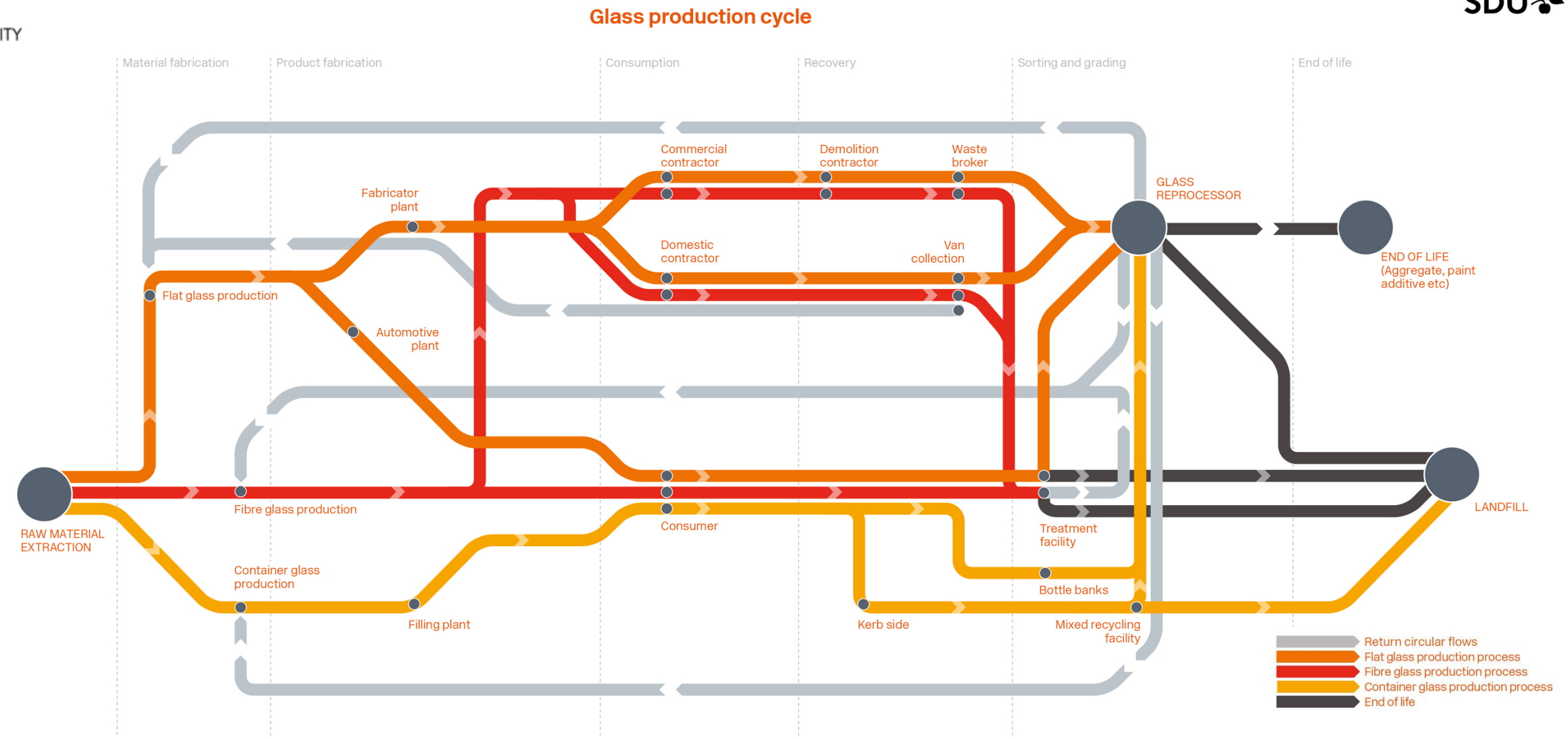




3R: REDUCE, REUSE, RECYCLE

CONSTRUCTION MATERIAL PYRAMID
CINARK

image credits: CINARK



3R: REDUCE, REUSE, RECYCLE

GLASS PRODUCTION CYCLE
Eckersley O'Callaghan And Cambridge University

image credits: Eckersley O'Callaghan And Cambridge University

3R: REDUCE, REUSE, RECYCLE

DIGITAL CITY
CHSarquitectos

image credits: Cortesía de CHSarquitectos

3R: REDUCE, REUSE, RECYCLE

FLOAT GLASS CULLET
sorted

image credits: Al Taj Al Thamin

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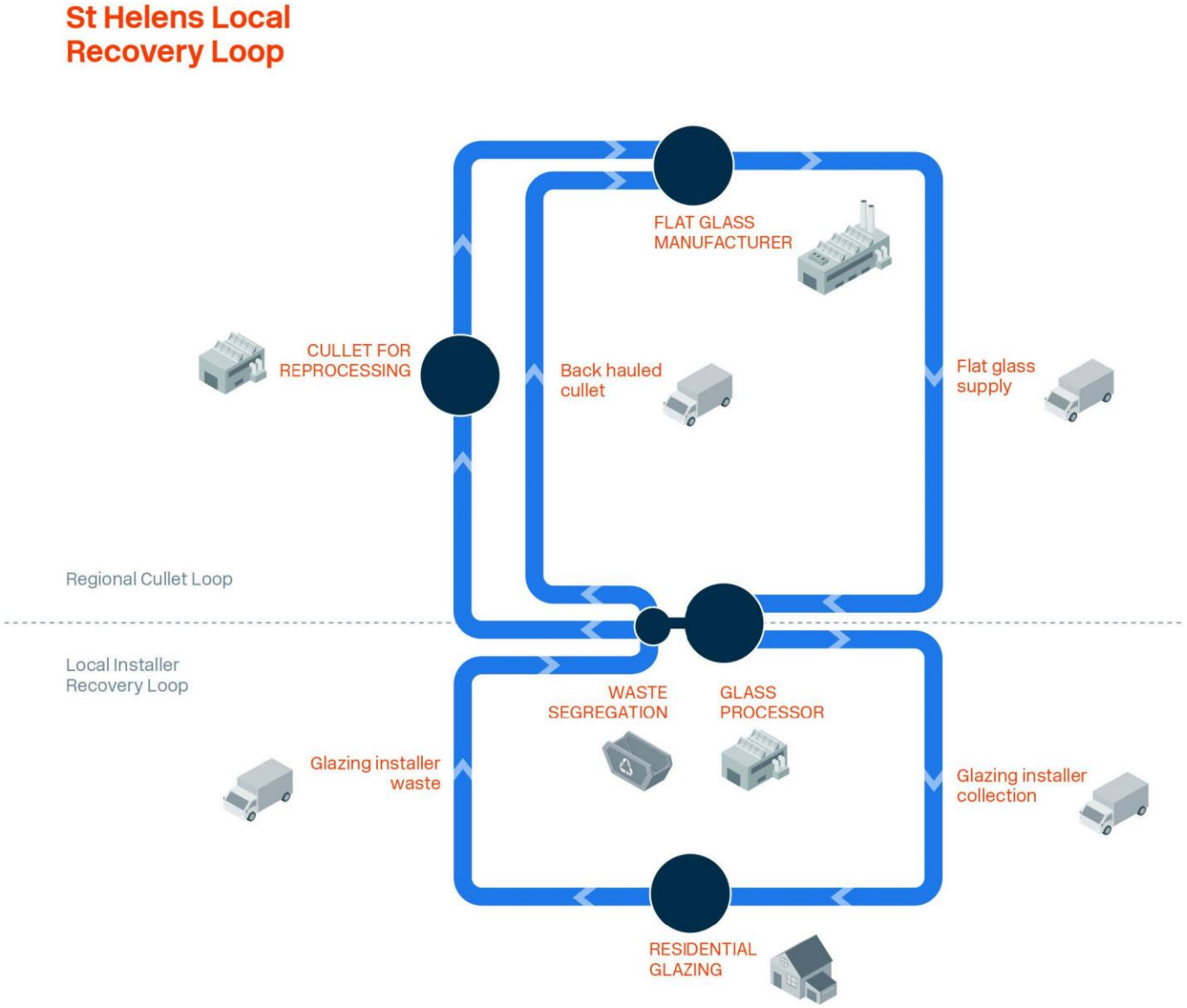


3R: REDUCE, REUSE, RECYCLE

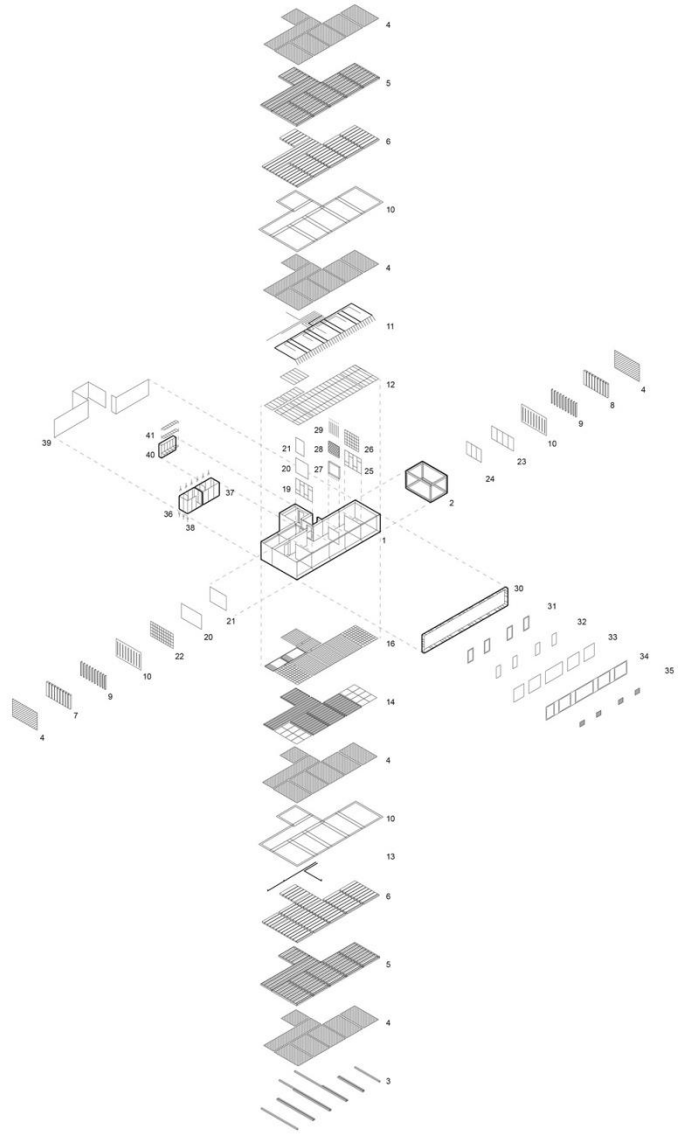
GLASS RECOVERY LOOP
Eckersley O'Callaghan And Cambridge University

image credits: Eckersley O'Callaghan And Cambridge University

DESIGN FOR DISASSEMBLY AND MAINTENANCE

NEST EMPA IN DÜBENDORF, SWITZERLAND
the UMAR (Urban Mining & Recycling)

image credits: Wojciech Zawarski



DESIGN FOR DISASSEMBLY

NEST EMPA IN DÜBENDORF, SWITZERLAND
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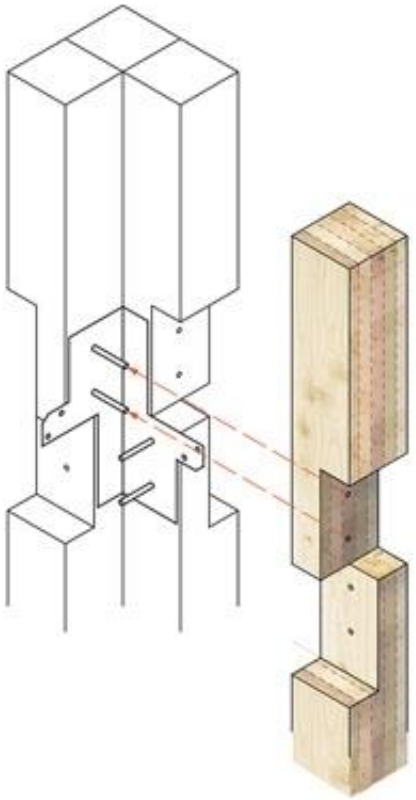
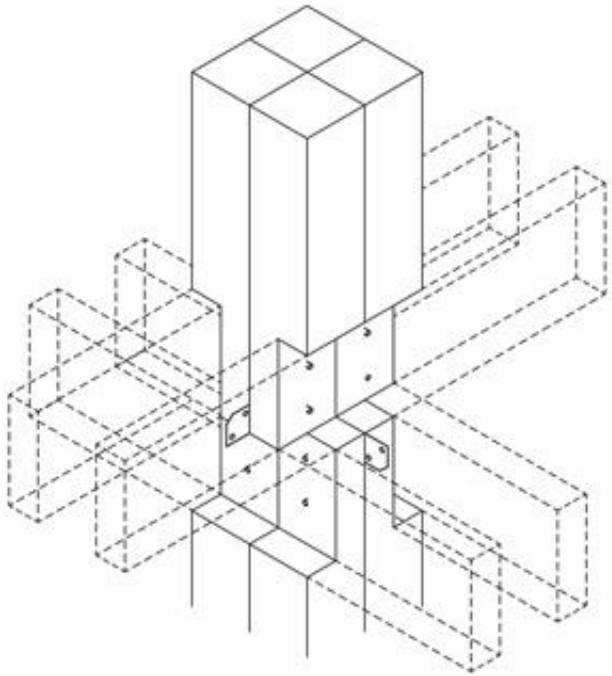
image credits: UMAR

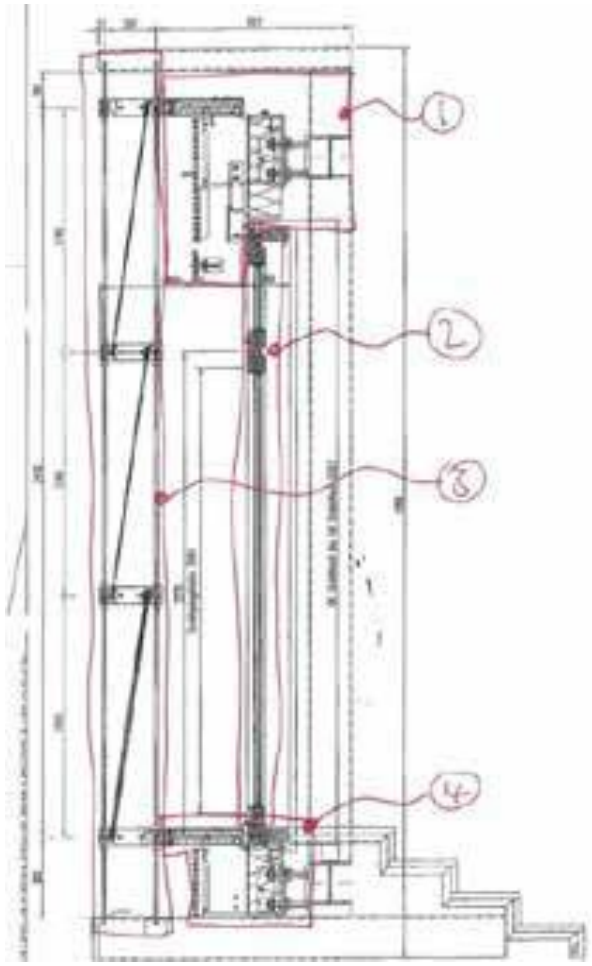




DESIGN FOR DISASSEMBLY

Nest We Grow
Kengo Kuma & Associates + UC Berkeley

image credits: Shinkenchiku Sha



Component	Part	Image	Material	Reason	Assembly	Reuse	Recycle
-	Cushion (attached to cap)		EPDM spacer cushion	Weather resistance	Bonded	No, not easily de-bonded	No
Rod connection assembly	-		-	-	-	-	-
-	Screwed block - lower		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Screwed block - upper		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Rotation pin		Stainless steel	Corrosion resistance	Sliding fit	Yes	Yes
-	Washer		Acetal	Low friction & isolation from aluminium	Trapped	Yes	Yes
Glass	Lower pane	-	Laminated	Operator safety	Trapped	Yes	No
-	Upper panes	-	Tempered	Cost	Trapped	Yes	Yes

DESIGN FOR DISASSEMBLY

AUTOPSY – FAÇADE TEARDOWN AT FRENER & REIFER

Frener Reifer and Arup

image credits: Frener Reifer and Arup

MATERIAL PASSPORTS, MATERIAL BANKS

image credits: Getty Images

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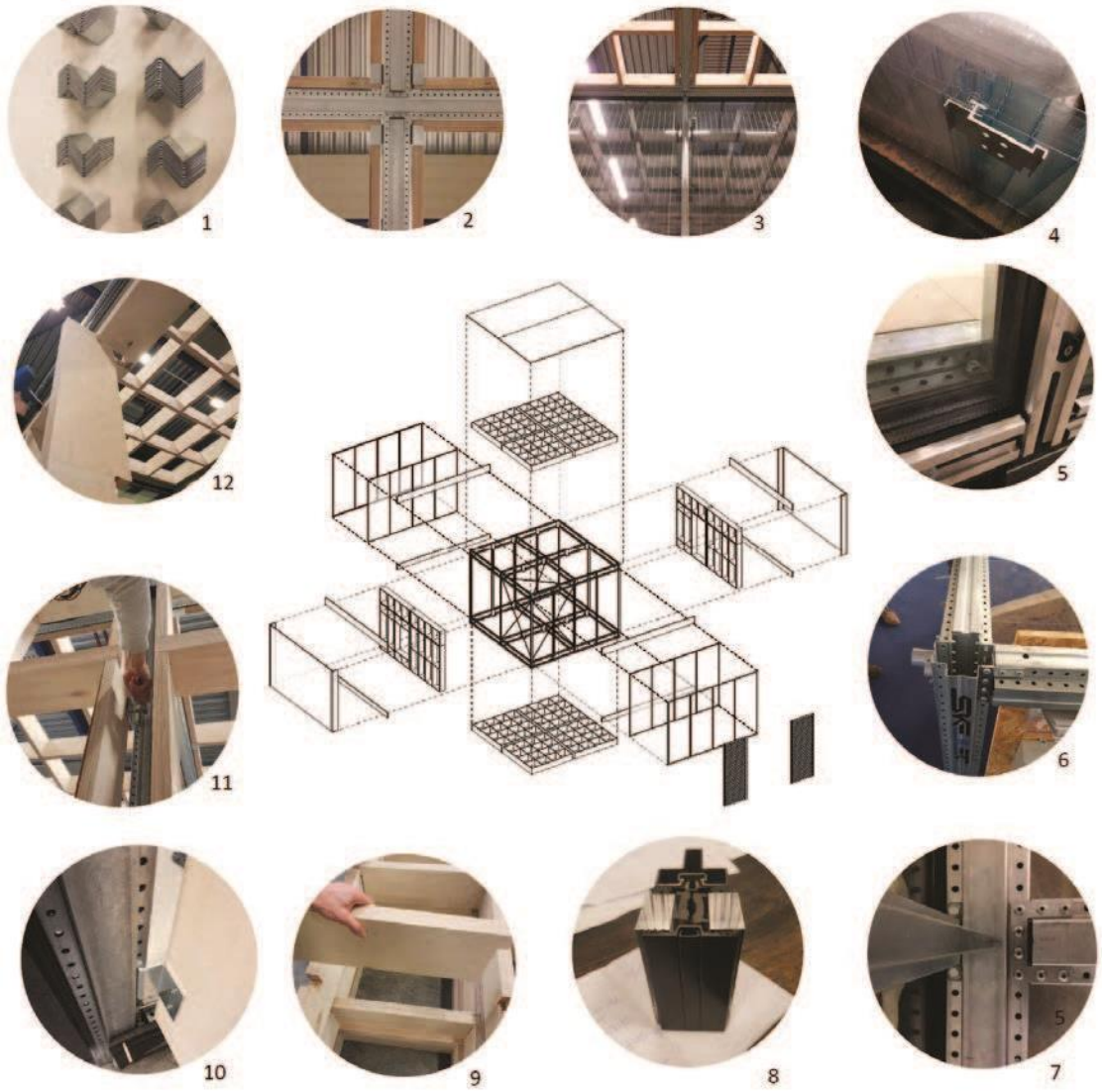
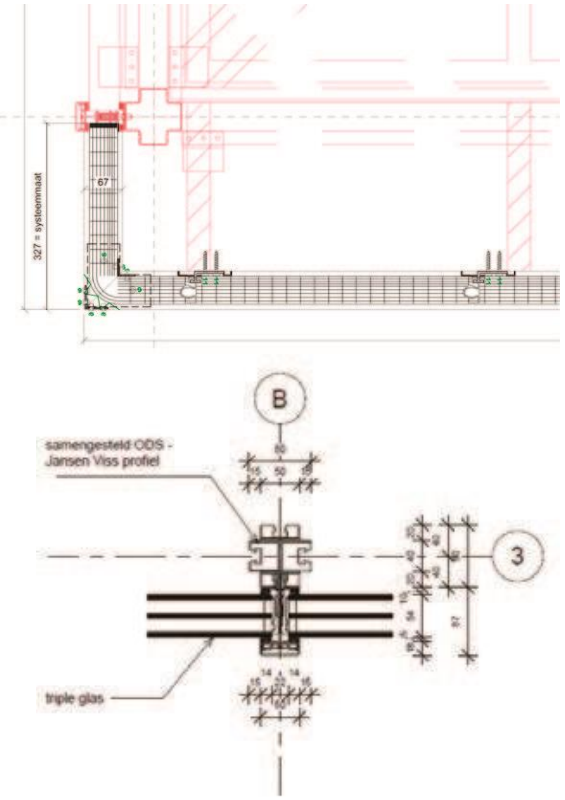
BAMB
BUILDINGS AS MATERIAL BANKS





MATERIAL PASSPORTS, MATERIAL BANKS

BAMB2020 PROJECT
BAMB 2020, GTB Lab Module

image credits: GTB Lab consortium

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EME

THE MOST VALUABLE MATCH

1. Resources Passport

The Resources Passport is a standardised and modular format to provide any material with an identity. This (digital) passport gives an insight into e.g. the composition, the origin, the toxicity or deconstructability of the material or product.

2. Tracking and Tracing

With tracking and tracing identifiers like barcodes, QR codes and chips, we effectively match physical materials to their digital twin the Resources Passport. This makes it possible to follow them throughout their life cycles.

3. Valuation

We quantify the financial, environmental and societal impact of materials, products and waste streams, enabling data-driven decision making between several next use options.

4. Matchmaking

We match the material, product or waste stream to a new high-value reuse option across industries, using a combination of Artificial Intelligence and human expertise.

MATERIAL PASSPORTS, MATERIAL BANKS

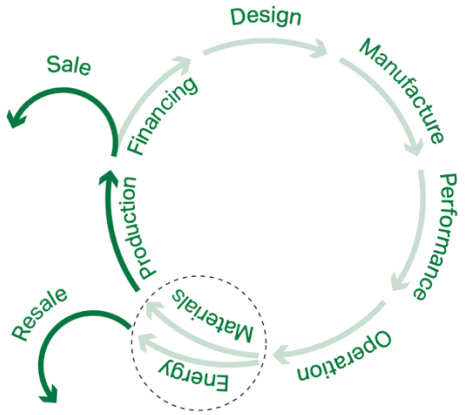
RESOURCE PASSPORT
EME

image credits: EME

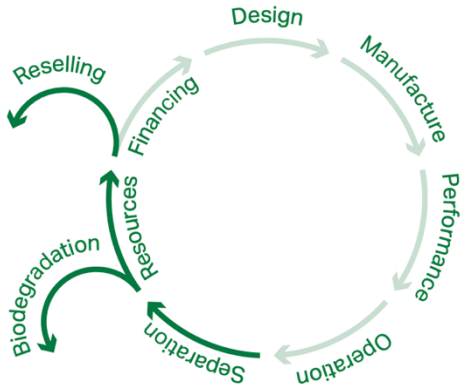
MATERIAL PASSPORTS, MATERIAL BANKS

WASTELAND – FROM WASTE TO ARCHITECTURE
Lendager Group's Exhibition At Dac 2017

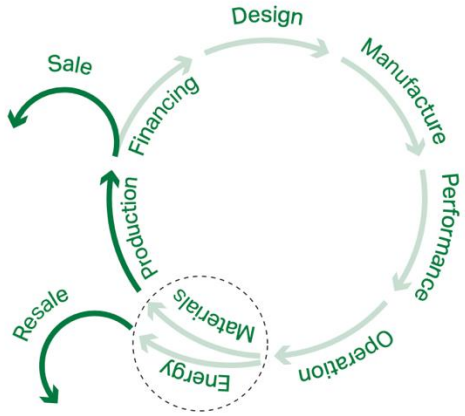
image credits: Rasmus Hjortshøj COAST



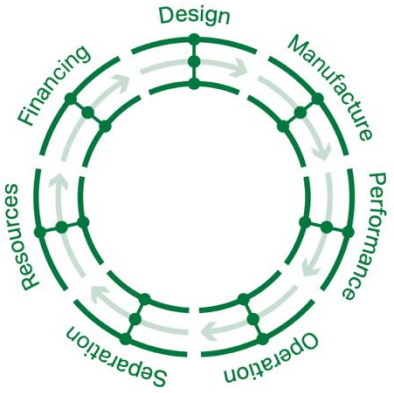
1. Circular supply chain



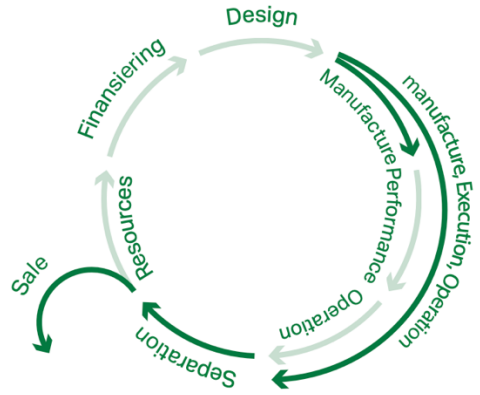
2. Recovery and Recycling



3. Product Life Extension



4. Sharing Platform



5. Product as a Service

CIRCULAR BUSINESS MODELS

BUILDING A CIRCULAR FUTURE
GXN

image credits: GXN

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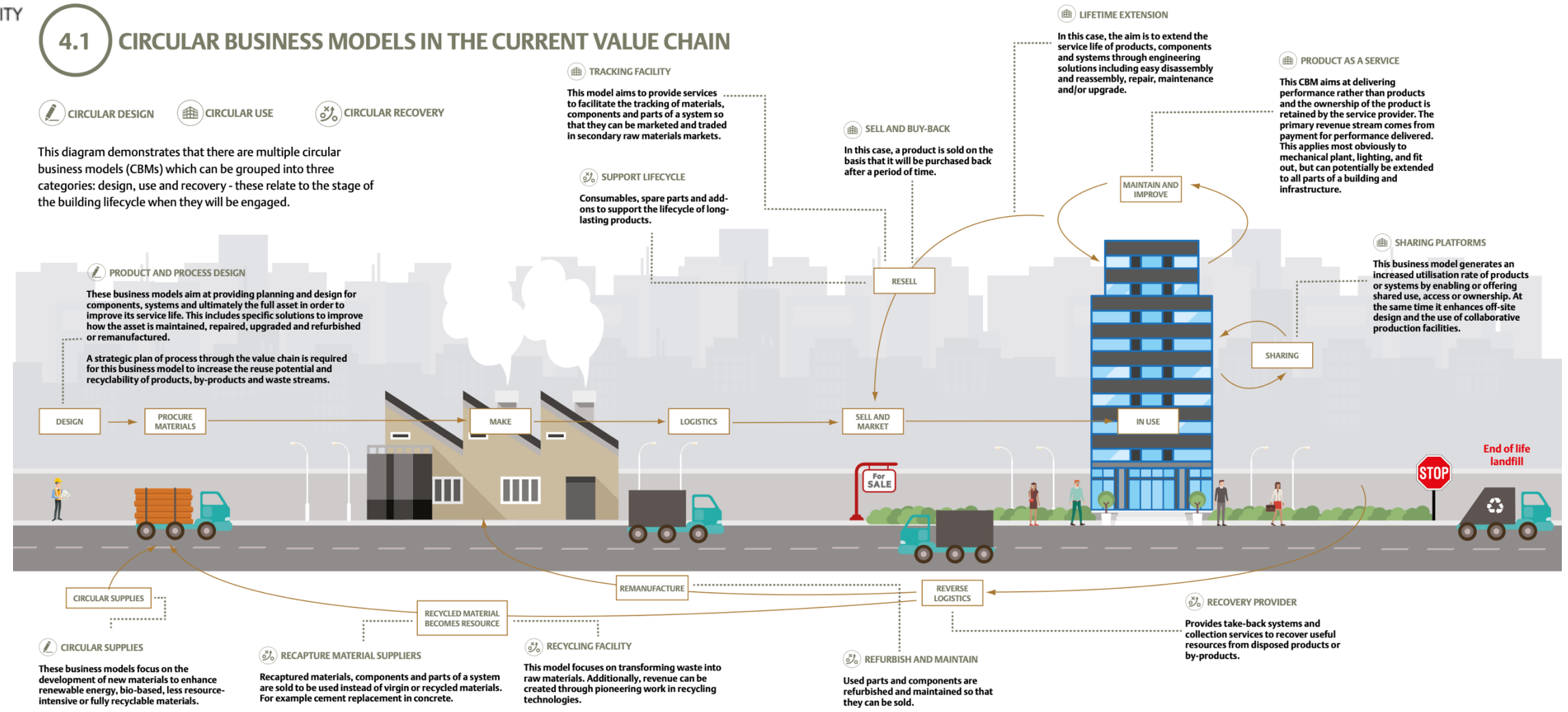
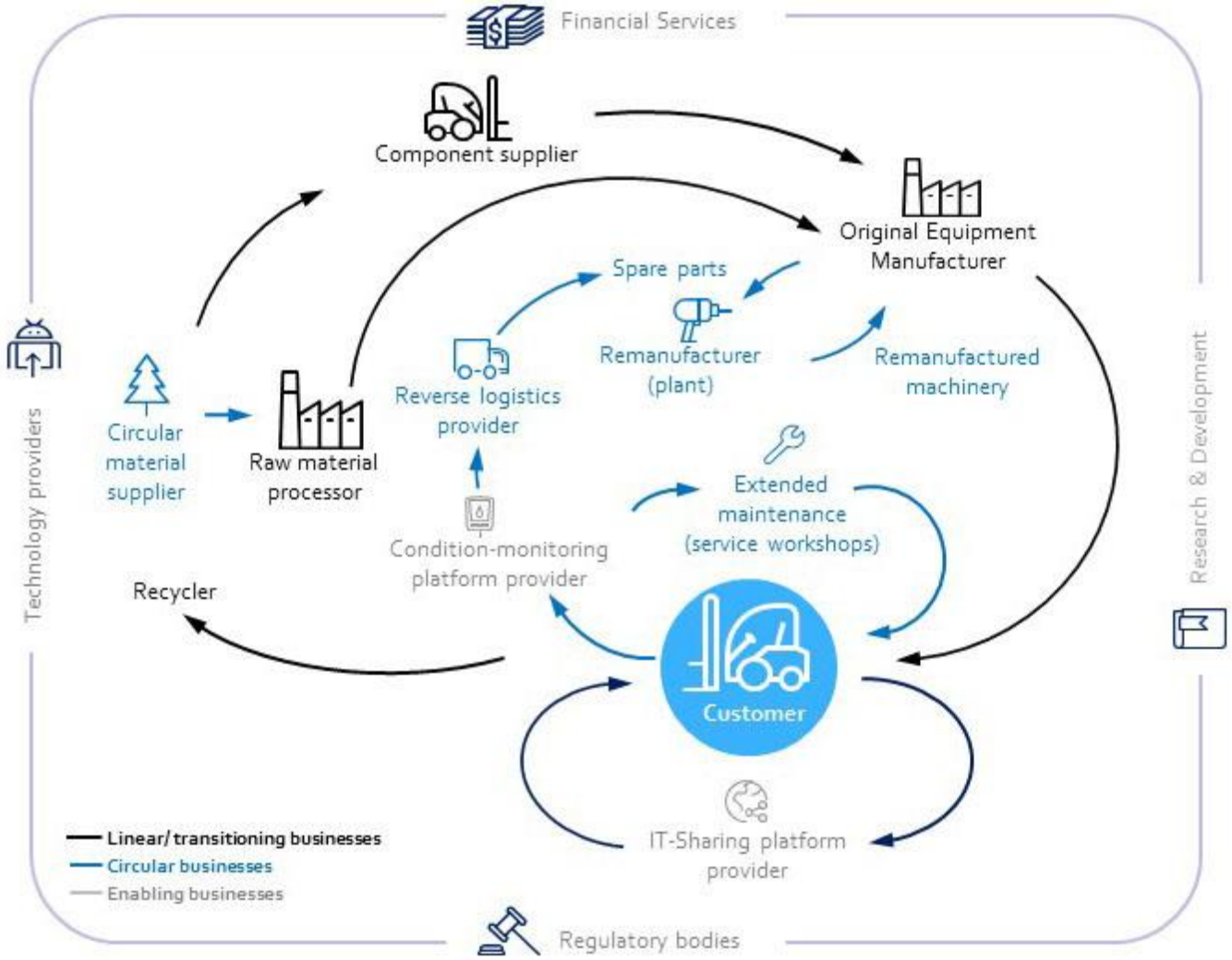


CIRCULAR BUSINESS MODELS

CURRENT VALUE CHAIN
Ellen Macarthur Foundation, Arup, bam, CE100

image credits: EMF, Arup, ba, CE100



CIRCULAR BUSINESS MODELS

NORDIC ECOSYSTEMS
Nordic Innovation

image credits: Nordic Innovation

CIRCULAR DESIGN PROCESSES

WASTELAND – FROM WASTE TO ARCHITECTURE
Lendager Group's Exhibition At Dac 2017

image credits: Rasmus Hjortshøj COAST

CIRCULAR DESIGN PROCESSES

WASTELAND – FROM WASTE TO ARCHITECTURE
Lendager Group's Exhibition At Dac 2017

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CIRCULAR DESIGN PROCESSES

RESOURCE ROWS, ØRESTAD SYD
Lendager

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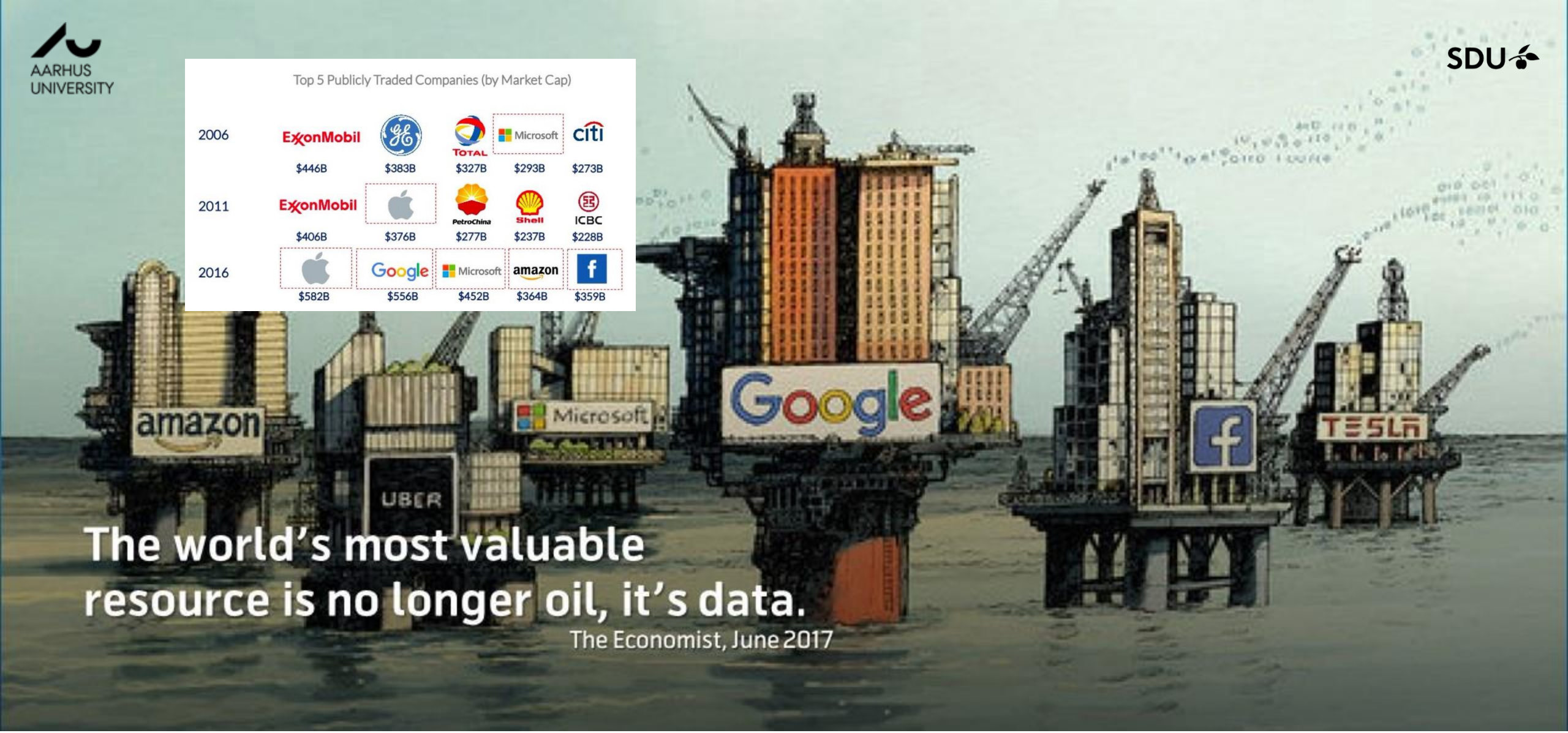
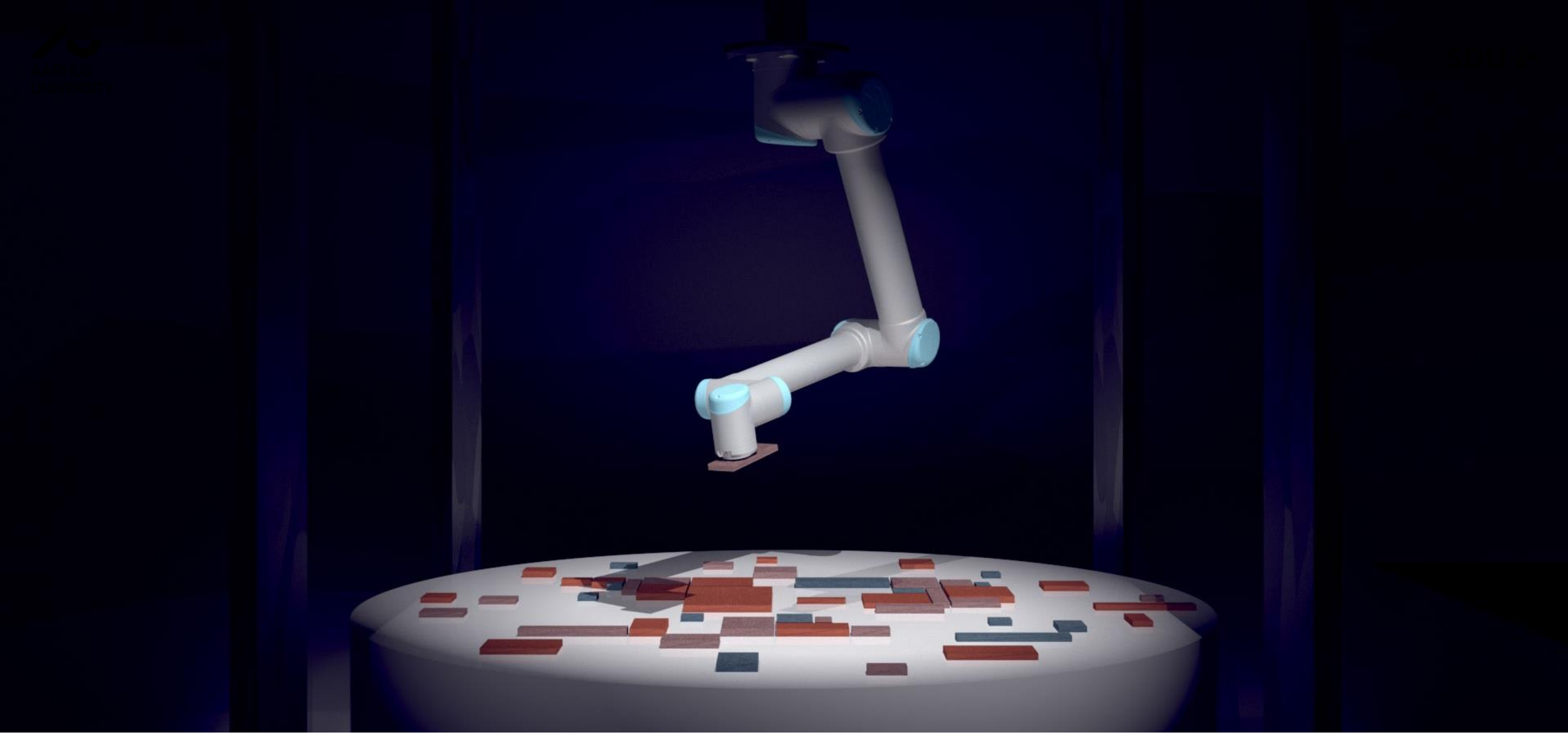


CIRCULAR CONSTRUCTION 4.0

BIG DATA
The Economist

image credits: The Economist



CIRCULAR CONSTRUCTION 4.0
MACHINE VISION

SCRAPCRETE
Certain Measures

image credits: Certain Measures

CIRCULAR CONSTRUCTION 4.0
RFID

CALUMENLIVE
Saint Gobain

image credits: Saint Gobain

CIRCULAR CONSTRUCTION 4.0
DIGITAL TWINS

PROJECT DASHER
Empa and Autodesk

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REGENERATIVE BUILD

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REGENERATIVE BUILDING OBJECTIVES

01

To create and run a sustainable regenerative organisation that makes a positive difference

We aim to create an organisation that not only advocates for but also actively embodies regenerative principles. The centre, in other words, should have a positive impact on nature, environment, and society, including a focus on CO_2 footprint, climate, biodiversity, ethics, and human well-being.

02

To promote interdisciplinary collaboration that can advance the built environment in a regenerative direction

We want to develop the best possible framework for collaboration between research, education, and the private sector. The goal is to create systemic change through new forms of collaboration and knowledge networks driven by personal commitment and high expertise.

03

To support the regenerative paradigm shift through a holistic approach to knowledge and research

We will assist the industry in the deep transition to regenerative building by employing an open approach to research, evidence, and learning. Sciences as diverse as agroecology, anthropology, biology, chemistry, sociology, and economics should be invited to participate and contribute.

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REGENERATIVE BUILDING OBJECTIVES

04

To incorporate evidence-based knowledge about people and nature into the future's ethical aesthetics

We will initiate an evidence-based dialogue on the interaction between nature, people, and built environment, and how the relationship between these three elements will impact everything from financing and urban planning to architecture and the execution of future construction projects.

05

To promote learning and knowledge through experiments and practical application

We want to build a culture where theory and dialogue are always followed by implementation. We believe that learning occurs when ideas and visions meet reality, and therefore, pilot projects, prototypes, and practical testing will play a significant role in our work.

06

To contribute to defining regenerative building in a Danish context

We want to ensure that all relevant stakeholders in Denmark understand the rationale behind a regenerative built environment. We will achieve this through our projects and knowledge-sharing, as well as by being consistently visible in the public debate about the role of construction in the future.

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07

To function as an international hub for knowledge

We will collaborate closely with leading international research and knowledge centres in regenerative thinking. Only by assembling and sharing knowledge internationally can we ensure that we learn from the best and become the best at sharing knowledge ourselves.

08

To promote the financing of basic and applied research

We will work to secure long-term and sustainable financing for both basic research and research-based demonstration projects within regenerative building. We will seek funding from both established and new sources, Danish as well as international, private as well as public.

09

To be a credible and independent conversation partner

We aim to be an internationally recognized knowledge centre for anyone seeking guidance and advice within regenerative building, whether they are legislators, researchers, engineers, or architects. We will work independently and build credibility through our research and communication.

REGENERATIVE BUILDING OBJECTIVES

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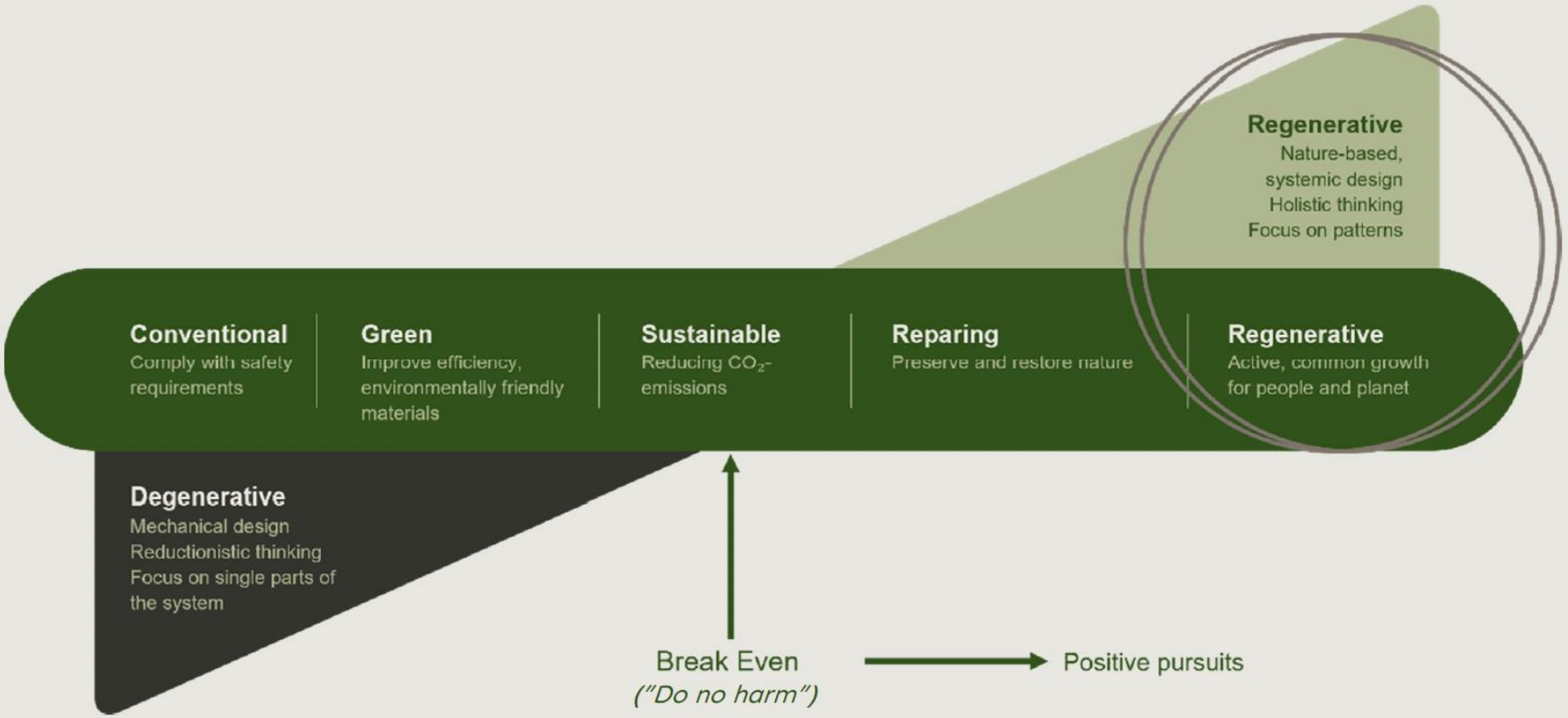
REGENERATIVE BUILDING DESIGN

Regenerative Building Design

Søren Jensen



REGENERATIVE BUILDING

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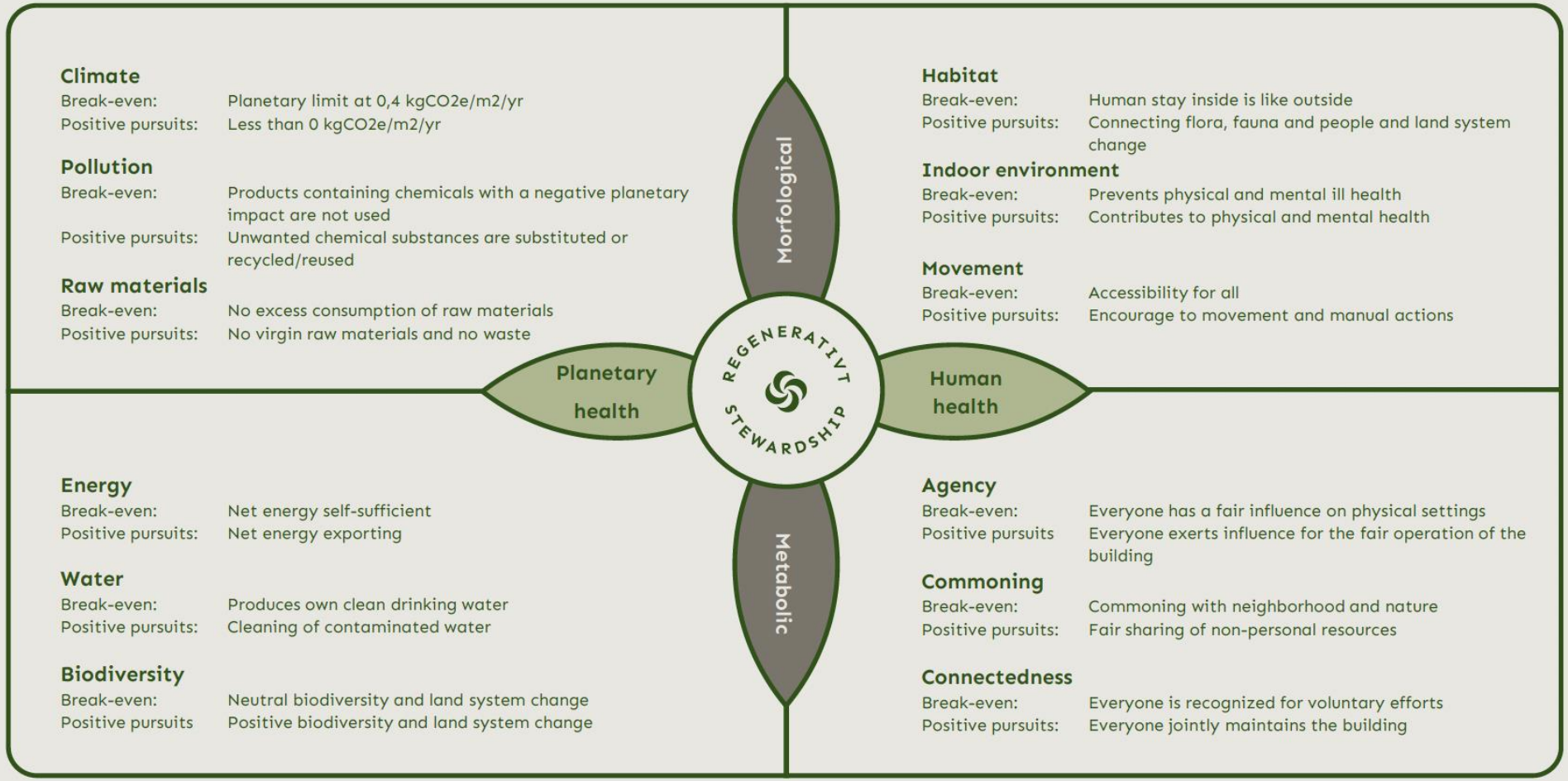
REGENERATIVE BUILDING DESIGN

Søren Jensens preliminary 12 indicators for regenerative building design

Søren Jensen



REGENERATIVE BUILDING

THE CIRCULAR FAÇADE
The new paradigm of regenerative building

MIKKEL K. KRAGH
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Department of Civil and Architectural Engineering, Faculty of Technical Sciences, Aarhus University, Denmark

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image credits: Quentin Olbrechts